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Amphibians and Reptiles of Luzon Island, V: The Herpetofauna of Angat Dam Watershed, Bulacan Province, Luzon Island, Philippines

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Abstract We report amphibian and reptile distribution records based on recent biodiversity surveys conducted at the Angat Watershed Reservation, Bulacan Province, Luzon Island, Philippines. This watershed constitutes the principal water source for Manila, the Philippines' largest metropolitan area. As virtually nothing is known of the herpetological diversity of the immediate area and the surrounding Bulacan Province, all species recorded as part of our surveys constitute major geographical records and/or significant range extensions. Our data result in a total of 63 new records of amphibian (19 frogs) and reptile (22 lizards, 2 turtles, and 20 snakes) species for this protected area (and immediate vicinity) that serves as a watershed for the major metropolitan area of Manila and surrounding cities. Together with the few previous literature records, our new records bring the total number of amphibian and reptile species for Bulacan Province to 68. We discuss several strategies for future survey work (focusing on habitat type, seasonal variation, and elevational variability) that we anticipate will result in increased knowledge of diversity within the Angat Watershed Reserve. The impressive level of herpetological diversity within such a small area, so close to Metro Manila, emphasizes that the diversity and distribution patterns of amphibians and reptiles from Luzon are still poorly known and in need of further study.

Keywords amphibians, Angat Dam, diversity, Philippines, reptiles

1. Introduction

The value of ecosystem services cannot be disputed for major metropolitan areas in Southeast Asian island nations (Collins *et al.*, 1991; Tomich *et al.*, 2004; Sodhi *et al.*, 2008; Corlett, 2009; Sodhi and Erlich, 2010). Intact, forested, surface-water catchment watersheds provide large portions of the resident human population with renewable forest resources, food, protection from inclement weather, flood and storm surge control, and most importantly, large quantities of fresh water for irrigation and direct human consumption (Dudgeon, 1992; Ratner, 2000; Thapa, 2001; Pattanayak, 2004). And yet, because of the pressures of the surrounding human population, many watershed reserves must be fiercely protected or fall subject to gradual settlement and encroachment, water quality degradation, overhunting, unregulated timber harvesting, and other non-sustainable harvest of renewable forest resources (Sodhi *et al.*, 2008). Due to the intense pressures associated with dense human populations concentrated near major metropolitan areas (Yuen and Kong, 2009), watershed resource managers are often left with little alternative other than to strictly regulate access to key watershed areas near

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large cities (Tomich *et al.*, 2004; Sodhi *et al.*, 2008). The unintended end result may be curtailed academic study, limited access afforded to biodiversity specialists, and impeded accumulation of knowledge concerning resident biodiversity at critical forested watersheds near human population centers.

On the Philippine island of Luzon, Angat Dam has provided hydroelectric power and water to the city of Manila for the past 40 years. The 55 700 ha Angat Watershed Metro Water District was established in February 1927. Construction of the Angat Hydroelectric Dam began in 1961 and the site was operational by September 1967. Angat Watershed Reservation (AWR) is located 35 km northeast of metro Manila (14.817°–15.217° N, 121.133°–121.333° E) within the municipalities of Angat and Norzagaray in Bulacan and Rizal Provinces at the southern end of the Sierra Madre Mountain Range (Figure 1).

More than 200 perennial and intermittent streams and rivers drain the Angat Watershed, including 11 major rivers (Talagyo, Maguong, Maputi, Kartmon, Matulid, Macau, Angat, Ipo, Pako, Sapang, and Anginan). Approximately 90% of the watershed is covered with virgin forest (dipterocarp forest accounts for 76.1% of the total watershed area). Submarginal forest and mossy forest cover 5.7% and 5.4%, respectively, of the reserve (DOST, 2011). Elevations within the watershed vary from 40–1300 m (DOST, 2011). Largely uninhabited, with development strictly curtailed and harvesting of forest products prohibited, the only permanent residents within the reserve are Dumagat tribespeoples with ancestral claims from before the establishment of the watershed (Briones and Castro, 1986) and watershed managers and security personnel. Despite protective legislation and highly effective local enforcement, logging and poaching remain a significant threat to the flora and fauna of the reserve.

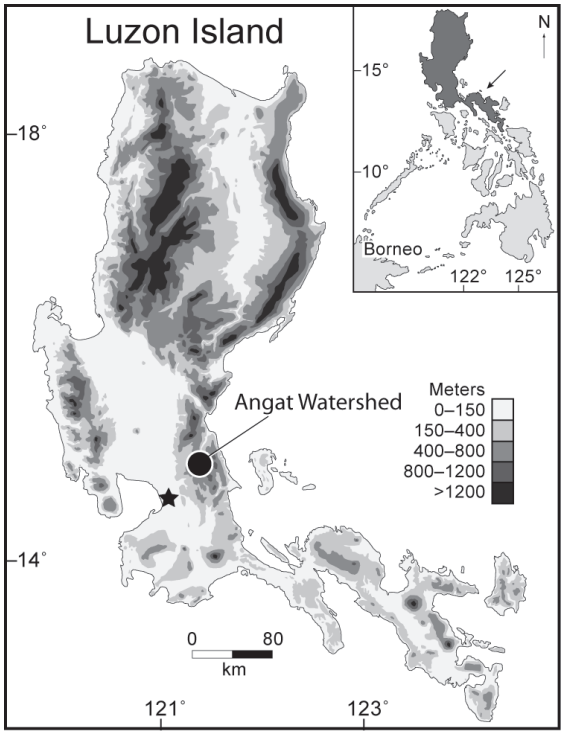

Figure 1 Map of Luzon Island, Philippines. The inset shows the location of Luzon Island (darkly shaded) within the Philippines. Elevation contours are indicated with incremental shading, and the position of the Angat Dam Watershed is indicated by a black circle. The position of the capital city, Manila, is indicated with a black star.

Since its inception, no comprehensive biodiversity survey has been undertaken at AWR. In 2010 a multi-year survey of the vertebrate fauna of AWR was initiated through a collaborative effort involving the National Power Corporation of the Philippines (NAPOCOR), the National Museum of the Philippines (PNM), and the University of Kansas Biodiversity Institute (KU). In this paper, we report on the first intensive herpetological survey for Bulacan Province and the AWR, the fifth in a series of surveys of Luzon Island's herpetofauna. Although still incomplete, our attempts to document the biodiversity of amphibian and reptile fauna of the AWR contribute to a growing understanding of regional and local patterns of montane microendemism of the Luzon faunal region (Taylor, 1920; 1922a, b; Ross and Gonzales, 1992; Brown *et al.*, 1996, 2000a, in review; Diesmos *et al.*, 2005; Welton *et al.*, 2010; Siler *et al.*, 2011; Balete *et al.*, 2011), and, on a larger scale, enhanced understanding of patterns of distribution of Philippine biodiversity (Brown and Diesmos, 2009; Diesmos and Brown, 2011). By initiating the AWR surveys, our eventual goal is to contribute to a greater public understanding of the crucial value of ecosystem services (principally fresh water) provided by biodiverse surface-water catchment watersheds of the Philippines—and to emphasize the role that natural populations of amphibians and reptiles play in ecosystem services that humans rely on everyday.

2. Methods

The collections summarized in this inventory consist of amphibian and reptile species recorded within the Angat Dam Watershed, collected using standardized field survey methods and specimen preparation protocols (Heyer *et al.*, 1994; ASIH, 2004). From November 2010 to June 2011, teams of biologists visited Bulacan

Province, Luzon Island, Philippines, and conducted biodiversity surveys in the following sites within the AWR (Figures 2–3): Location 1: 275 m elevation, Angat Watershed (outside reservoir), Barangay San Lorenzo, Municipality of Norzagaray (14.904˚ N, 121.150˚ E; surveyed 26 December 2010); Location 2: 114 m elevation, Angat Watershed, Sitio Bitbit, Barangay San Lorenzo, Municipality of Norzagaray (14.0˚ N, 54.022˚ E; surveyed 29 May 2011); Location 3: 318 m elevation, Angat Watershed, Settlement area around hydroelectric facility, Barangay San Lorenzo, Municipality of Norzagaray (14.9016° N, 121.1533° E; surveyed 27–30 May 2011); Location 4: Sitio Iligan, Barangay San Lorenzo, Municipality of Norzagaray (14.917° N, 121.200° E; surveyed 8–20 October 2010); Location 5: 194 m elevation, Angat Watershed, Langud Maliit River drainage, Sitio Langud, Barangay San Lorenzo, Municipality of Norzagaray (14.9329° N, 121.2056° E; surveyed 24–29 December 2009; 27–28 December 2010); Location 6: 208 m elevation, Angat Watershed, Langud River, drainage, Sitio Langud, Barangay San Lorenzo, Municipality of Norzagaray (14.9316° N, 121.2079° E; surveyed 31 May–4 June 2011); Location 7: 226 m elevation, Angat Watershed, Sitio Talagyo, Barangay Kabayunan, Municipality of Doña Remedios Trinidad (15.0333° N, 121.2032° E; surveyed 6–11 June 2011); Location 8: 80 m elevation, limestone formations along the national road, Barangay Bigte, Municipality of Norzagaray (14.916° N, 121.047° E; visited 5 May 2011) on the access route into the Angat watershed (ACD, personal observations). Specimens were preserved according to standard protocols (Simmons, 2002; ASIH, 2004) and voucher specimens were deposited at KU and PNM. We searched the literature and museum holdings at the United State National Museum (USNM), the Field Museum of Natural History (FMNH), Harvard University's Museum of Comparative Zoology (MCV), the Carnegie Museum (CM), and the California Academy of Sciences (CAS) for Bulacan Province records and include those in this report as well.

3. Results

Species Accounts: Specimens examined and sites corresponding to where voucher specimens were collected are presented in Table 1. Species accounts follow:

Amphibia

Bufonidae

***Rhinella marina* (Linnaeus, 1758):** This introduced and invasive species (Diesmos *et al.*, 2006) co-occurs in human-inhabited areas (AWAT facility, residents compound, overlook area, Bitbit River) of the Angat Watershed. This species is common in highly disturbed habitats and can often be heard calling in loud breeding choruses in flooded agricultural fields and irrigation canals. This species has also been recorded in the nearby Municipality of San Miguel (USNM 344840–41) (Figure 4A).

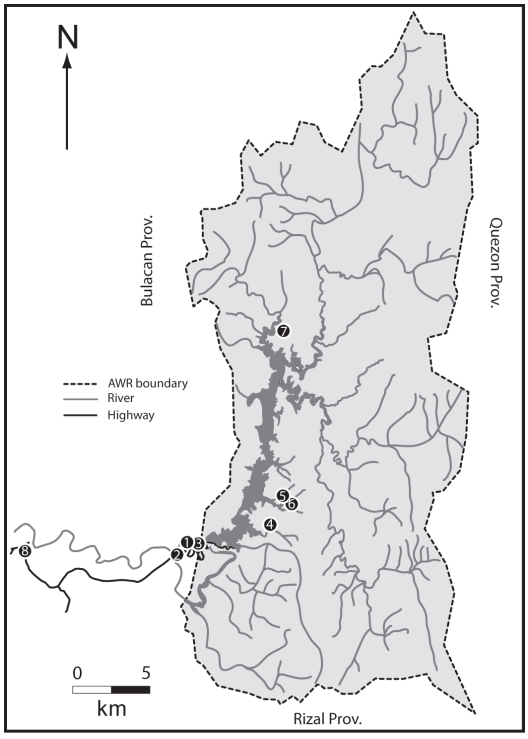

Figure 2 Map of Angat Watershed Reserve, including numbered cites visited as part of the survey (See text for explanation and description).

Ceratobatrachidae

***Platymantis corrugatus* (Duméril, 1853):** This terrestrial species was found sympatrically with *P. mimulus* and *P. dorsalis* in forested areas of Sitios Iligan, Langud, and Talagyo. Whereas *P. mimulus* and *P. dorsalis* most often call from exposed perches, or while sitting on top of leaf litter, *P. corrugatus* males were observed frequently hiding beneath the cover of dry leaf litter (Figure 4B).

***Platymantis dorsalis* (Duméril 1853):** Males were observed calling from stream banks, low vegetation (< 1 m), and from the tops of stumps and fallen logs in forested areas of Sitios Iligan, Langud, and Talagyo. The recognition of numerous cryptic species in the *P. dorsalis* complex (Brown *et al.*, 1997a, 1999a; Alcala *et al.*, 1998; Alcala and Brown, 1999) suggests that morphological data alone may not be sufficient to confidently diagnose these species and emphasize the importance of molecular and

advertisement calls to resolve complex taxonomic issues pertaining to this group (Figure 4C–D).

***Platymantis luzonensis* Brown, Alcala, Diesmos, and Alcala 1997:** This arboreal species is known from low- to mid-elevation forests of the Angat Reservoir in addition to Mt. Makiling, Mt. Banahao, and the volcanoes of the Bicol Peninsula in southern Luzon Island (Brown *et al*., 1997b). This species was observed calling from sapling branches and leaves at Sitio Talagyo and Iligan, and from shrubs and bamboo (as high as 4–5 m above ground) at Sitio Langud (Figure 4E).

***Platymantis mimulus* Brown, Alcala, and Diesmos 1997:** Originally described from Laguna Province (Brown *et al.*, 1997a), this species was found at all sites surveyed at the Angat Reservoir. In disturbed and pristine areas alike, males call from forest floor leaf litter or dry, suspended litter in the branches of shrubs and herbaceous vegetation.

***Platymantis polillensis* (Taylor 1922):** Originally described from Polillo island (to the east of Bulacan Province), this species has been considered a critically endangered small island endemic (Alcala and Custodio, 1995; Alcala and Brown, 1998; IUCN, 2011) until recent discovery of at least one morphologically similar (e. g., *P. sierramadrensis*) species (Brown *et al.*, 1997c, 1999b), additional populations of uncertain status (Brown *et al.*, 2000a) and eventual reports of true *P. polillensis* (Siler *et al.*, 2011; Brown *et al.*, in review) were reported for several sites along the east coast of Luzon. Although this species has not yet been recorded from sites along the shores of the Angat Lake, it has been positively identified by advertisement call in a highly disturbed scrubby area atop limestone formations along the national road, Barangay Bigte, Municipality of Norzagaray, (80 m, above sea level) on the access route into the Angat watershed (ACD, personal observations). We therefore consider this an unconfirmed species at Angat watershed pending the collection of voucher specimens. Nevertheless, given the widespread distribution of this common species (Brown *et al.*, unpublished data), we are confident that it will be recorded within the reserve's main drainage during future sampling efforts, especially during the onset of the rainy season (June–August).

***Platymantis pygmaeus* Alcala, Brown, and Diesmos 1998:** This species was found only at Sitio Talagyo (the site most characterized by the absence of bamboo). Individuals were found in forest floor leaf litter and herbaceous vegetation (Alcala *et al.*, 1998) 1–4 km away from streams and on steep stream banks in syntopy with *Platymantis* sp. and *P. dorsalis* (Figure 4F).

***Platymantis* sp.:** This small-bodied species was observed on steep cliffs and limestone formations at the banks of small closed-canopy streams in primary forest at Location 7. This undescribed species possesses distinctive morphological traits, an advertisement call unlike any heard elsewhere in the Philippines (RMB and ACD, personal observations), and a distinct microhabitat preference for steep soil and/or limestone cliffs bordering deep, ravine-like creeks. It has so far only been recorded at Sitio Talagyo. Other Philippine *Platymantis* that share similar microhabitat preferences include the phenotypically distinct and geographically distant Mt. Malinao cliff frog, *P. diesmosi*, (Brown and Gonzales, 2007), and *P. pseudodorsalis* which is endemic to Mt. Banahao (Brown *et al*., 1999a) (Figure 4G).

Dicroglossidae

***Hoplobatrachus rugulosus* (Wiegmann 1834):** This species has been collected on multiple occasions from the compound settlement area surrounding the hydroelectric facility and along on the bank of the Bitbit River. This species occurs throughout China and Southeast Asia, and was recently introduced into the Philippines (Diesmos *et al.*, 2006) where it has been found on Luzon, Mindanao, Mindoro, and Palawan. It is often found in rice paddy and agricultural areas and is known to be a human commensal. Its common name (Chinese Edible Frog) belies the economic importance of this species which is often farmed and sold as food resource. This fact most likely contributed to its introduction into the country in the late 1990s (Diesmos *et al.*, 2006).

***Limnonectes macrocephalus* (Inger 1954):** This large bodied fanged frog was observed at all sites surveyed within the Angat Reservoir. Individuals of this large species were found near water sources ranging from small temporary pools to the banks of streams. This species is widely distributed throughout all islands within the Luzon Pleistocene Aggregate Island Complex (PAIC; Brown and Diemos, 2002) (Figures 4H, 5A).

***Limnonectes woodworthi* (Taylor 1923):** This medium-sized species is often found syntopically with *L. macrocephalus* on southern Luzon (Taylor, 1920; Inger, 1954; Diesmos, 1998; Siler *et al.*, 2011) and can be differentiated by the presence of dorsal and dorsolateral folds, a dark tympanic region, and smaller adult body size. Individuals of this species were found near water sources ranging from small temporary pools to the banks of streams at Sitios Iligan, Langud, and Talagyo (Figure 5B).

***Occidozyga laevis* (Günther 1858):** This species is found throughout the Philippines in shallow, slow-moving streams, small pools of water in disturbed habitats, and

Figure 3 Examples of habitats sampled at Angat Dam Watershed. A: Angat reservoir and dam viewed from look-out area at guest house facility; B: The Bitbit River flows from the base of Angat Dam and supplies water for irrigation and to metro Manilla; C: Angat Reservoir is relatively unpopulated, however there are small communities of Dumagat living along the banks of the reservoir; D–F: The Langud River and its tributaries are closed-canopy, rocky streams with sand-gravel substrate. Photos by DSM.

muddy pools utilized by water buffalo (Taylor, 1920; Inger, 1954). We also observed this species at the edges of closed-canopy mountain streams. Differences in external morphology and natural history habits of this species may be an indication that this widespread taxon represents multiple, independent evolutionary lineages.

Figure 4 Anurans from Angat Dam Watershed. A: *Rhinella marina* (specimen not collected); B: *Platymantis corrugatus* (KU 329395); C–D: *Platymantis dorsalis* (KU 329048–49) showing color pattern variation; E: *Platymantis luzonensis* (KU 329011); F: *Platymantis pygmaeus* (KU 329033); G: *Platymantis* sp. (KU 329062); H: *Limnonectes macrocephalus* (uncataloged PNM specimen), color morph from Location 3. Photos A, B, and H by DSM, all others by RMB.

We observed this species at nearly all sites in the study area (Table 1) and it has also been recorded in the nearby Municipality of San Miguel (USNM 344842) (Figure 5C).

Microhylidae

***Kaloula* cf. *kalingensis* Gray 1831:** This species is found exclusively in tree-holes and water-filled cavities of

bamboo stems 0.5–4.0 m above the ground (the preferred site of egg deposition; Brown and Alcala, 1982). These arboreal frogs have large, expanded toe pads, and we observed individuals in both primary and secondary forests, as well as in dense low elevation bamboo stands at Langud, Langud Maliit, and Talagyo (Table 1). This species, which is widely distributed in the Philippines, may represent a complex of distinct evolutionary lineages (Inger, 1954; Diesmos *et al.*, 2002) (Figure 5D).

***Kaloula pulchra* Gray 1831:** Several individuals of this introduced and invasive species (Diesmos *et al.*, 2006) were collected while calling from shallow pools beneath limestone outcrops along the Bitbit River near human settlements. Until recently, this species was known to have a widespread distribution throughout much of Southeast Asia except for the Philippines; however, it has now been introduced to the country, recently been documented on Luzon (Diesmos *et al.*, 2006; Siler *et al.*, 2011), and likely now occurs on other Philippine islands.

Ranidae

***Hylarana erythraea* (Schlegel 1837):** This wide ranging, introduced species (Diesmos *et al.*, 2006) was found around temporary or stagnant water sources in the vicinity of the hydroelectric compound, along the Bitbit River, and the AWAT Facility. Specimens were observed in heavily disturbed habitat as well as near the edges of a secondary forest (Langud Maliit River).

***Hylarana similis* (Günther 1873):** This species of cascade stream frog is widely distributed throughout the Luzon PAIC (Brown and Guttman, 2002). We observed *H. similis* in pristine streams and rivers, usually in areas with some form of forest cover at Sitios Iligan, Langud, and Talagyo, as well as at several small streams along the last 5 km of road leading into the Angat manager's compound (Figure 5E).

***Sanguirana luzonensis* (Boulenger 1896):** We encountered this common stream frog in a variety of riparian habitats from large and heavily disturbed rivers to small streams in pristine forest. The species exhibits a highly polymorphic dorsal color pattern (e. g., brilliant green, tan, dark brown, or mottled brown and black; Inger, 1954; Brown *et al.*, 2000b; Fuiten *et al.*, 2011) (Figure 5F).

Rhacophoridae

***Polypedates leucomystax* (Gravenhorst 1829):** This widespread arboreal rhacophorid tree frog is found most often in disturbed habitat and residential areas around temporary pools of water. Most of our specimens were encountered at the hydroelectric compound among residential areas, along the Bitbit River, or along the road leading to Angat. At Sitio Langud, a single female was found in a grassy clearing near the bank of Angat reservoir in an area of mixed bamboo and dipterocarp forest. A recent phylogenetic study of the species revealed nearly all populations in the Philippines to be genetically identical to one another, an indication that the species may have recently been distributed throughout the country due to the activities of humans (Brown *et al*., 2010). *P. leucomystax* constructs foam nests on surfaces overhanging or near stagnant pools of water (Brown and Alcala, 1982).

***Rhacophorus appendiculatus* (Günther 1858):** This infrequently encountered species has a widespread distribution throughout the Philippines (Inger, 1954; Brown and Alcala, 1994), occurring in disturbed, secondary and primary forests. We encountered a single individual, situated on leaves of a shrub above a temporary pool in the forest at Talagyo. This is an additional species known to build foam nests on vegetation overhanging pools of water (Brown and Alcala, 1982) (Figure 5G).

***Rhacophorus pardalis* Günther 1858:** Specimens were collected on elevated vegetation overhanging stream-side pools in forest at Sitios Iligan, Langud, and Talagyo. This species is known to have a widespread distribution throughout much of the Philippines, and also constructs foam nests on vegetation above stagnant pools of water (Inger, 1954; Brown and Alcala, 1982) (Figure 6A).

Reptilia (Lizards)

Agamidae

***Bronchocela marmorata* (Gray 1845):** We found this species asleep at night on branches of trees and shrubs in disturbed forest. Similar to the results of a recent survey in Aurora Province, Luzon Island (Siler *et al.*, 2011), some specimens collected approximately match the definition of *B. marmorata* (nuchal crest scales moderate, equal to diameter of orbit, only dorsal-most crest scales pointing dorsally) while others in the same population appear to fit the diagnosis of *B. cristatella* (nuchal scales shorter than diameter of orbit, upper 5–10 crest scales pointing dorsally; Hallermann, 2005). We hesitate to refer these specimens to two species (Hallerman, 2005) becase differences are so slight and appear to represent points along a continual range of intrapopulational ontogenetic variation; we suspect the variation observed here represents natural intraspecific variation within one species. Individuals were often found 2–4 m above the ground. This species is widely distributed in the Philippines (Figure 6B).

***Draco spilopterus* (Wiegmann 1834):** This species is

Figure 5 Anurans from Angat Dam Watershed. A: *Limnonectes macrocephalus* (KU 329133), color morph from Location 4; B: *Limnonectes woodworthi* (KU 329189); C: *Occidozyga laevis* (KU 329252); D: *Kaloula kalingensis* (KU 329017); E: *Hylarana similis* (specimen not collected); F: *Sanguirana luzonensis* (KU 329289); G: *Rhacophorus appendicularis* (KU 329311). Photos C, E, and G by RMB, all others by DSM.

widespread throughout much of the central and northern Philippine islands (McGuire and Alcala, 2000). It is commonly observed on Luzon in coconut groves on the trunks and canopies of coconut trees where it feeds exclusively on ants and termites (McGuire and Alcala, 2000). We collected this species at the edge of a disturbed

forest in human settlements as well as on tree trunks in mixed dipterocarp forest at Sitios Langud and Talagyo.

***Gonocephalus sophiae* (Gray 1845):** We collected individuals of this species at night asleep on the trunks of small trees and saplings in secondary-growth forest at Sitios Langud and Talagyo. Our specimens match the definition of *G.sophiae* (Taylor, 1922a), as do most specimens collected at other sites on southern Luzon (Alcala, 1986) such as recent records from Aurora Province (Brown *et al.*, 2000b; Siler *et al.*, 2011) (Figure 6C).

Gekkonidae

***Cyrtodactylus philippinicus* (Steindachner 1867):** This common species is endemic to the northern and west-central islands of the Philippines and were found at all forested sites surveyed. A comprehensive phylogenetic study of Philippine *Cyrtodactylus* based on DNA sequence data shows populations from Luzon Island do not form a clade (Siler *et al*., 2010a), suggesting that eventual resolution of this complex may result in the recognition of more than one species (Figure 6D).

***Gehyra mutilata* (Wiegmann) 1834:** This species, together with *Hemidactylus frenatus* and *H. platyurus*, make up the three common, widespread species of house geckos in the Philippines. We encountered individuals of *G. mutilata* on the buildings at the AWAT station. This species has also been recorded in the nearby Municipality of San Miguel (USNM 344863).

***Gekko gecko* (Linnaeus 1758):** This species is known to occur throughout the Philippines with the exception of the Batanes and Babuyan Island group (Oliveros *et al*., 2011). Specimens were collected at night only within the main Angat complex (Figure 6E).

***Gekko mindorensis* Taylor 1919:** This species has a wide distribution throughout the Philippine islands (Brown and Alcala, 1978; Siler *et al.*, 2011). We encountered a single specimen at the watershed overlook area of the main Angat complex. The recognition of diversity of Philippine *Gekko* has steadily increased over the years (Brown and Alcala, 1978; Brown *et al.*, 2008, 2009; Linkem *et al.*, 2010a). A recent phylogenetic study (Siler *et al.*, in press), demonstrates that the widespread species *G. mindorensis* is made up of eight deeply divergent clades, an indication that future taxonomic work is needed to clarify species boundaries within this complex.

***Hemidactylus brookii* Gray 1845:** Although not recorded in the Angat Watershed proper, this species has been found in the nearby Municipality of San Miguel, Barangay Bulualto (USNM 344864–67).

***Hemidactylus frenatus* Schlegel 1836:** This house gecko occurs throughout the Philippine archipelago and was collected in both forested (Sitio Langud) and disturbed areas within the AWR. Individuals were found at night near lights on residential buildings. This species has been found in the nearby Municipality of San Miguel, Barangay Bulualto (USNM 344868–86) (Figure 6F).

***Hemidactylus platyurus* (Schneider 1792):** This house gecko was observed but not collected at the AWAT facility and main hydroelectric compound, on the external walls of buildings beneath lights at night. This species has also been recorded in the nearby Municipality of San Miguel (USNM 344844–62).

***Lepidodactylus lugubris* (Duméril and Bibron 1836):** This species is less frequently observed in the northern Philippines (Brown and Acala, 1978), but does appear to be patchily distributed at a few sites on Luzon Island (RMB, personal observation), although the few specimens accumulated in museum collections have originated from forested areas, which is atypical for the species (suggesting ecological differences which may indicate taxonomic distinctiveness). An individual of this species was found at night on leaves of a tree 4.5 m above ground at Sitio Langud and may represent the same species observed recently in Aurora Province (Siler *et al.*, 2011) (Figure 6G).

Scincidae

***Brachymeles bonitae* Duméril and Bibron 1839:** *Brachymeles bonitae* is a limb-reduced species of skink that is often encountered under rotting logs and in loose soil surrounding the root networks of large trees (Brown and Alcala, 1980). This species, as currently recognized, is widely distributed across the northern Philippine islands (Siler and Brown, 2010). Recent phylogenetic studies of the genus *Brachymeles* have not supported its monophyly (Siler *et al*., 2011; Siler and Brown, 2010), and- thus, *B. bonitae* likely represents a complex of morphologically similar but unique evolutionary lineages worthy of taxonomic recognition. Unlike many species in the genus, *B. bonitae* appears to be a forest obligate species (Siler and Brown, 2010). In the AWR, only a single specimen was collected and the most undisturbed site (Sitio Talagyo) surveyed.

***Brachymeles boulengeri* Taylor 1922:** We collected individuals of this species under rotting logs, piles of coconuts, and loose soil and leaf litter surrounding the roots of trees in low elevation, disturbed and secondary-growth forest at Sitios Langud and Iligan. This species was recently elevated to full species (Siler and Brown, 2010), and is known to have a wide geographic distribution, occurring on Luzon, Marinduque, Masbate,

Figure 6 Amphibians and reptiles from Angat Dam Watershed. A: *Rhacophorus pardalis* (KU 329314); B: *Bronchocela marmorata* (KU 329325); C: *Gonocephalus sophiae* (KU 329332); D: *Cyrtodactylus philippinicus* (KU 329339); E: *Gekko gecko* (uncataloged PNM specimen); F: *Hemidactylus frenatus* (KU 329356); G: *Lepidodactylus lugubris* (KU 329361); H: *Sphenomorphus decipiens* (KU 329401). Photo G by RMB, all others by DSM.

and Polillo Islands (Brown and Alcala, 1980; Siler and Brown, 2010).

***Eutropis multicarinata borealis* (Brown and Alcala 1980):** This polytypic species occurs in Malaysia (Borneo), Indonesia, the Palau islands, Taiwan (China), and the Philippines, where two subspecies have been

described (Brown and Alcala, 1980). *Eutropis m. multicarinata* is currently recognized to occur in the Mindanao PAIC, and *E. m. borealis* is widely distributed throughout the central and northern Philippine islands. We observed individuals of this medium-sized ground skink on leaf litter in disturbed habitats.

***Eutropis multifasciata* (Kuhl 1820):** We collected individuals of this species in and around debris in disturbed riparian habitats near human settlements within the AWR. Males of this species possess polymorphic (yellow, green, or orange) patches of brightly colored scales on the lateral surfaces of their body. At Sitio Langud this species was frequently collected in mammal snap-traps as it presumably came to feed on insects attracted to rodent bait. This species occurs throughout the Philippines (Brown and Alcala, 1980; Alcala, 1986) and has also been recorded in the nearby Municipality of San Miguel, Barangay Bulualto (USNM 344887–94).

***Lamprolepis smaragdina philippinica* (Mertens 1928):** Similar to *Draco spilopterus*, this arboreal scincid lizard is commonly observed on the trunks of coconut trees in disturbed habitats in coastal areas of Luzon Island. At the AWR, this species was encountered 2–4 m above the ground on tree trunks in the forest. This species was recorded only on the banks of the Bitbit River and in Sitio Talagyo, but we suspect it occurs throughout lakeshore habitats within the AWR.

***Sphenomorphus abdictus aquilonius* (Brown and Alcada 1980):** This species is part of a large complex of distinct evolutionary lineages that require comprehensive taxonomic revision before identification of any one lineage can be confidently established (Brown and Alcala, 1980; Linkem *et al.*, 2010b). This medium-sized species of ground skink can be found in a wide variety of secondary and primary forest among the leaf litter, under logs, and along streams and rivers. Our specimens were collected in riparian habitats at Sitios Iligan, Langud, and Talagyo.

***Sphenomorphus cumingi* (Gray 1845):** *Sphenimorphus cumingi* is a very large, actively foraging, ground dwelling skink. Some of our specimens were collected in mammal traps where they presumably came to feed on insects attracted to rodent bait. This species was also observed basking on rocky outcroppings and foraging among the leaf litter.

***Sphenomorphus decipiens* (Boulenger 1894):** This is a small-bodied, forest obligate species found in leaf litter on the forest floor of intact forest. Our single specimen was collected in mixed primary and secondary growth forest at Sitio Langud (Figure 6H).

***Sphenomorphus leucospilos* (Peters 1872):** Until recently, this species was believed to be quite rare (Brown and Alcala, 1980), and prior to recent surveys, was known from only two specimens collected on Luzon Island (Brown *et al.*, 2000a; Siler *et al.*, 2011). We observed this species under leaves, woody debris, and rocks along quick-flowing forest streams and waterfalls. When disturbed, individuals dove into the water or quickly crawled into crevices between rocks. Populations observed at the AWR have a distinct color pattern that differs slightly from other populations on Luzon Island (Siler *et al.*, 2011; RMB and CDS, personal observation) (Figure 7A).

***Sphenomorphus steerei* Stejneger 1908:** This species was found in secondary and primary forests in leaf litter and woody detritus at Sitios Langud and Talagyo (Figure 7B).

Varanidae

***Varanus marmoratus* (Wiegmann 1834):** A single individual of this large carnivorous species of monitor lizard was salvaged from a local hunter passing through our camp at Sitio Langud. This species, commonly encountered throughout the Luzon faunal region, was reportedly collected in a stream-side trap (baited with fish of the genus *Talapia*) in secondary forest.

***Varanus olivaceus* Hallowell 1857:** A single individual of this large, rare, frugivorous species of monitor lizard was salvaged from a Dumagat hunter near the Langud River drainage where it was allegedly treed with hunting dogs. This species is morphologically and genetically distinct from *Varanus bitatawa* (Welton *et al.*, 2010), which is known to occur in small remnant forest patches in northeastern Luzon and Aurora Provinces to the north of Angat (Welton *et al.*, 2010). *V. olivaceus* occurs throughout remnant forest patches in southeastern Luzon, Catanduanes, and Polillo islands (Auffenberg, 1988). Frugivorous monitors in the Philippines feed on the fruits of several palm species (*Corphya elata*, *Livistonia rotundifolia*, *Caryota* sp.), fig species (*Ficus altissima, F. merritti, F. benjamina, F. balete*), and pandanus fruit (*Pandanus tectorius*) (Auffenberg, 1988; Gaulke, 2010). This specimen is the northern most geographical record for *V. olivaceus* (Auffenberg, 1988; Welton *et al.*, 2010) (Figure 7C).

Reptilia (Snakes)

Colubridae

***Ahaetulla prasina preocularis* (Taylor 1922):** We collected this common species of vine snake (Leviton, 1967) asleep on branches of shrubs in secondary-growth

forest at Sitio Iligan. This species is widely distributed in the Philippines (Leviton, 1967).

***Boiga dendrophila divergens* Taylor 1922:** This species was observed near rivers in disturbed forest habitats. Individuals were observed resting on tree branches 4–6 m above ground (Sitio Langud) or were encountered on the ground while actively hunting at night (Sitio Talagyo). This polytypic species occurs throughout the Philippines (Leviton, 1970), and consists of four subspecies (Levion, 1963a, 1970) (Figure 7D).

***Calamaria gervaisii* Duméril, Bibron, and Duméril 1854:** This burrowing species was found in sandy-loam soil at Sitio Langud. Two species of *Calamaria* occur on Luzon Island, with *C. gervaisi* being considerably smaller and morphologically distinct from the robust-bodied species *C. bitorques*, which is known from Aurora Province to the north (Brown *et al.*, 2000a; Siler *et al.*, 2011). We suspect that future surveys conducted at the AWR will result in observations of a local population of *C. bitorques* (Figure 7E).

***Coelognathus erythrurus manillensis* Jan 1863:** This large, polytypic species of rat snake has been observed throughout much of the Philippines (Leviton, 1979) and other parts of the islands of Southeast Asia (Helfenberger, 2001). We collected individuals of this species in the disturbed forest surrounding the main Angat hydroelectric facility.

***Chrysopelea paradisi* Boie 1827:** This widespread (Leviton, 1964a) species of "flying snake" was observed 3–4 m high in a tree at Sitio Talagyo as it preyed on a nest of young Bulbuls. Although the specimen evaded our capture by gliding into nearby saplings, our photographic records allow for positive identification of the species (Figure 7F).

***Cyclocorus lineatus lineatus* (Reinhardt 1843):** This species was collected under leaf litter and fallen logs in disturbed and secondary-growth forest at Iligan, Langud, and Talagyo. The species occurs throughout the Philippine islands (Leviton, 1965a) (Figure 8A).

***Dendrelaphis caudolineatus luzonensis* (Leviton, 1961):** A common Bronze Back snake in the Philippines (Leviton, 1961, 1968), this species was encountered only along the Bitbit River. This species is most often found 2–4 m above the ground on branches and shrubs at night.

***Dryophiops philippina* Boulenger 1896:** Historically, this widely distributed species was collected frequently throughout the country (Leviton, 1964a); in the last century encounters with this snake have become increasingly rare, most likely as a result of the fact that little low elevation and/or coastal forest remains in the country (Alcala, 1986). One specimen was collected in the morning in shrubs at Sitio Iligan.

***Hologerrhum philippinum* Günther 1858:** Considered quite rare, fewer than 25 specimens of this snake species exist in collections around the world (Brown *et al.*, 2001; Phenix *et al.*, in press). A single specimen was collected during mid morning under a rock in a dry stream bed at Sitio Langud Maliit, matching previous habitat and circumstances of capture reported for this species at other sites (Taylor, 1975; Brown *et al.*, 1996; ACD, personal observation) (Figure 8B).

***Lycodon capucinus* (Boie 1827):** We found individuals of this species under leaf litter and fallen logs in disturbed and secondary-growth forest. This species is one of at least nine resident Philippine species of the genus *Lycodon*, and is recognized to have a broad geographic distribution throughout the Philippines (Leviton, 1965b).

***Oligodon ancorus* (Girard 1858):** A single roadkill was collected from the national road, Barangay Bigte, Municipality of Norzagaray, (80 m asl) on the main access route into the southern portions of Angat watershed. We assume this seldom-collected but widely distributed, low elevation, coastal forest habitat specialist occurs throughout the AWR but we have not yet encountered it within the main watershed drainage.

***Ptyas luzonensis* (Günther 1873):** Formerly recognized as a member of the genus *Zaocys*, this species occurs throughout the central and northern Philippine islands (Leviton, 1983; Ross *et al.*, 1987). We found this species sleeping in branches of understory trees on the banks of streams at Sitios Langud and Talagyo (Figure 8C).

***Rhabdophis spilogaster* (Boie 1827):** A specimen of this natricine colubrid was collected in the late morning among rocks on the bank of a small running stream bed at Sitio Langud. An additional specimen with locality data "Angat Dam, Barangay Norgazaray" has been deposited at the U. S. National Museum (USNM 319147).

Elapidae

***Hemibungarus calligaster calligaster* (Wiegmann 1835):** A single specimen of this Philippine endemic coral snake was collected at Sitio Iligan from alongside a small stream in primary forest where it was active at mid-morning. Color variation in this individual appeared intermediate to described "subspecies" (*H. c. calligaster* and *H. c. mcclungi*; Leviton 1963b), consistent with recent observations of considerable color variation at different geographic regions within the species' range (Siler *et al.,* 2011; Siler and Welton, 2010). Although this species has been demonstrated to be part of a widespread mimicry complex involving lepidopteran larvae (Brown,

Figure 7 Reptiles from Angat Dam Watershed. A: *Sphenomorphus leucospilos* (KU 329388); B: *Sphenomorphus steerei* (KU 329112); C: *Varanus olivaceus* (salvaged from local hunter; KU 329517); D: *Boiga dendrophilia divergens* (KU 329425); E: *Calamaria gervaisi* (KU 329405); F: *Chrysopelea paradisi* eating young Bulbul (specimen not collected). Photos A and F by RMB, all others by DSM.

2006; Siler and Welton, 2010), we found no coral snake caterpillar mimics in the AWR.

***Ophiophagus hannah* (Cantor 1936):** Residents of the AWR and Dumagat tribes peoples related numerous instances of sightings and resident killings of very large, light tan colored cobras in the vicinity of settlements along the Angat lakeshore. We find these reports sufficiently credible to include this species in the present report, though will consider it unconfirmed until voucher specimens are procured. Whereas some sightings may be based on the Philippine Cobra (*Naja philippinensis*; a species which should also be present in Bulacan Province; Leviton, 1964b), numerous descriptions of very large body size in some of the accounts convince us that King Cobras may occur within the vicinity of the Angat Watershed.

Lamprophiidae

***Oxyrhabdium leporinum leporinum* (Günther 1858):**

Figure 8 Reptiles from Angat Dam Watershed. A: *Cyclocorus lineatus lineatus* (KU 329411); B: *Hologerrhum philippinum* (KU 328837); C: *Ptyas luzonensis* (KU 329295); D: *Trimereserus flavomaculatus* (KU 329422); E: *Typhlops ruficaudatus* (KU 329419); F: *Coura amboinensis amboinensis* (uncataloged PNM specimen). Photos B, D, and E by RMB, all others by DSM.

This species of burrowing snake is endemic to the Philippines, and has been observed throughout much of the country's central and northern islands (Leviton, 1964). We found juveniles of this species sleeping at night on herb layer vegetation on the bank of a small stream at Sitio Talagyo.

Viperidae

***Trimereserus flavomaculatus* Gray 1842:** We encountered individuals of this species of pit viper coiled at night on branches of trees in primary and secondary growth forest. This species has been noted previously to be highly polymorphic in coloration across its distribution (Siler *et al.*, 2011), and color characteristics often used to distinguish "subspecies" (Leviton, 1964b) have proven unreliable as diagnostic features of lineages (Siler *et al.*, 2011) (Figure 8D).

***Tropidolaemus subannulatus* (Gray 1842):** A single male of this common Luzon pit viper (Taylor, 1922b; Leviton, 1964b; Vogel *et al.*, 2007) was collected on a streamside shrub at Sitio Iligan. This species is most likely common within the watershed reserve.

Typhlopidae

***Ramphotyphlops braminus* (Daudin 1803):** We collected this species under fallen logs in disturbed and secondary growth forest at Sitio Langud.

***Typhlops ruficaudus* (Gray 1845):** *Typhlops ruficaudus*

Table 1 List of specimens arranged by sampling localities visited during surveys of the Angat Watershed Reserve. Descriptions of sampling locations are provided in the text. Unless otherwise indicated, all numbers refer to cataloged specimens deposited at the University of Kansas Biodiversity Institute (KU). Totals represent the numbers of species recorded from Angat Dam Watershed and Bulacan Province. Obs = Specimen observed but not collected; uncat. PNM = Uncataloged specimens housed at the Philippine National Museum.

		Location 1	Location 2 (Bitbit)	Location 3 (AWAT)	Location 4 Iligan	Location 5 Langud Maliit	Location 6 Langud	Location 7 Talagyo	Location 8 Bgite	San Miguel	Biak na Bato
Frogs	*Rhinella marina*		Obs	Obs						USNM 344840–41	
	Platymantis biak										319973–87 328713–18
	Platymantis corrugatus				328871–885		329017–022	329023–041			
	Platymantis dorsalis				328845–847		329042–047	329048–060			
	Platymantis luzonensis						329009	329010–016			
	Platymantis mimulus										327588
	Platymantis polillensis								Obs		
	Platymantis pygmaeus							329003–008			
	Platymantis sp.										
	Fejervarya cancrivora									USNM 344843	
	Hoplobatrachus rugulosus		329114								326975
	Limnonectes macrocephalus	328647–658	329128–132	329127 329451	328896–914 328916–924	328659–661 328915 328925–928	329133–168 329188	329169–187			
	Limnonectes woodworthi				328914	328705	329189–195	329196–205			
	Occidozyga laevis			329206	328888–890 328892	328665–667 328891 328893–895	329207–244	329245–254			326989
	Kaloula cf. *kalingensis*					328870	329295–296	329297–305			
	Kaloula pulchra		329306–307								326798
	Hylarana erythraea			329115–124			329125	329126			
	Hylarana similis				328848–855	328675–680 328856–857	329255–272	329273–281			
	Sanguirana luzonensis				328858–860	328861–869	329282–294				
	Polypedates leucomystax		329309	329308			329310				327091–92
	Rhacophorus appendiculatus							329311			
	Rhacophorus pardalis				328886–887		329312–314	329315–321			
Total	19 Angat, 22 Bulacan										
Turtles	*Cuora amboinensis amboinensis*		uncat. PNM								
	Pelodiscus sinensis		329424								
Total	2 Angat, 2 Bulacan										
Lizards	*Bronchocela marmorata*	328791	329322	uncat. PNM	328930–933	328790	329323–327	329328			
	Draco spilopterus			uncat. PNM		328929		329329–331	Obs		327738
	Gonocephalus cf. *sophiae*				328934–935		329332	329333–337			
	Cyrtodactylus philippinicus				328936–938		329338–340	329341–351			
	Gehyra mutilata			329354							327399–400
	Gekko gecko										319968–71
	Gekko carudensis										320484–85
	Gekko mindorensis			329355							319932–33

(Continued Table 1)

		Location 1	Location 2 (Bitbit)	Location 3 (AWAT)	Location 4 Iligan	Location 5 Langud Maliit	Location 6 Langud	Location 7 Talagyo	Location 8 Bgite	San Miguel	Biak na Bato
	Hemidactyluss brooki									USNM 344864–67	
	Hemidactylus platyurus			uncat. PNM						USNM 344844–62	327397
	Hemidactylus frenatus	328829	329359	329356–358			329360			USNM 344868–86	
	Lepiodactylus lugubris			329361							
	Brachymeles boulengeri				329362 329364–366			329367–370			
	Brachymeles bonitae				329363						
	Eutropis multicarinata				328944–945		329373–375				
	Eutropis multifasciata			329376	328939–943		329377	329378–379			
	Lamprolepis smaragdina		329280					329381	Obs		
	Sphenomorphus abdictus aquilonius				328949–954	328955		329402–404			
	Sphenomorphus cummingii				328948		329382–384	329385–387			327069
	Sphenomorphus decipiens				328946		329401				320071
	Sphenomorphus leucospilos							329388–392			
	Sphenomorphus steerei				328947		329393–397	329398–400			
	Varanus marmoratus						329428				
	Varanus olivaceus						329517				
Total	22 Angat, 24 Bulacan										
Snakes	*Ahaetulla prasina*				328960–961						327173
	Boiga dendrophila divergens		uncat. PNM			328966	329425	329426–27			
	Calamaria gerevaisi			329405–406	328956–958		329407	329408			
	Chrysopelea paradisi							Obs			
	Coelognathus erythrura										
	Cyclocorus lineatus				328973–975		329409–412	329413			
	Dendrelaphis caudolineatus luzonensis		329414			328967					
	Dryophiops philippina					328968					
	Hemibungarus calligaster calligaster					328977					
	Hologerrhum philippinum					328837					
	Lycodon capucinus					329415–416					
	Lycodon muelleri										327575
	Oligodon ancorus								328976		
	Ptyas luzonensis						329295	329430–432			
	Rhabdophis spilogaster					328969 USNM 19147	329418				
	Oxyrhabdium leporinum leporinum				328970 328972	328971	329417				
	Trimereserus flavomaculatus				328962–965		329420–421	329422–423			
	Rhamphotyphlops braminus					328840					
	Tropidolaemus subannulatus				328694						
	Typhlops ruficaudus				328959			329419			
Total	20 Angat, 20 Bulacan										

is an endemic Philippine blind snake, and has been documented on Luzon, Sibuyan, Marinduque, and Tablas islands (Wynn and Leviton, 1993). This species was observed in rotting organic material within and beneath logs in primary growth forest. Our specimens were collected from beneath rotting logs at Sitios Talagyo and Iligan (Figure 8E).

Reptilia (Turtles)

Bataguridae

***Cuora amboinensis amboinensis* Daudin 1802:** We found a single specimen of this widespread Asian box turtle (Diesmos *et al.*, 2008) in a man-made, concrete basin at the AWAT horticultural station. We expect that it is common around human settlements and agricultural land surrounding the AWR (Figure 8F).

Trionychidae

***Pelodiscus sinensis* (Wiegmann 1835):** We collected a single specimen of this introduced (Diesmos *et al.*, 2008) turtle in shallow, flowing water (< 15 cm deep) with a weak current at the edge of the Bitbit River.

4. Discussion

The results of our surveys provide additional baseline distribution data for the diversity of amphibians and reptiles of the AWR (Figure 1). The species encountered during our surveys include many interesting discoveries, potentially new species to science, many endemic species, and additional information on rare species known previously from very few observations and/or specimens. To date, our survey efforts at the AWR have been limited to locations in close proximity to the reservoir and at relatively low elevations (200–600 m, above sea level). Isolated areas of higher elevation (> 600 m, above sea level) and different river drainages within the AWR must now be explored to document the additional high elevation species that we anticipate will eventually be found and arrive at a comprehensive estimate of the reserve's herpetological diversity. We expect that many additional species will be recorded in Bulacan Province and within the vicinity of the AWR, once logistical obstacles to working at high elevations throughout the watershed can be overcome. Surveys at the onset of the rainy season (June-August) will be necessary to realize the full extent of amphibian diversity within the protected area.

There were notable differences in the faunal assemblages at the AWR sites we visited. The sites with the greatest diversity were those farthest from extensive human settlements (e. g., Sitios Iligan, Talagyo). At Sitios Iligan, Langud and Talagyo (Locations 4, 6 and 7), we recorded 25, 28, and 29 species, respectively, whereas we recorded 1–12 species at disturbed sites outside the AWR (Locations 1–3, 8). On streams bordering or inside the AWR that were within proximity of human settlements (Location 3), we observed telltale signs of human disturbance (hunting trails, cleared areas, signs of recreational activities, discarded waste), indicating a heavy human presence. Sitios Langud and Talagyo were relatively pristine, though both of these forested areas showed signs of historical logging, continued small-scale timber harvest, bamboo and pandanus harvesting, and hunting by Dumagat tribes peoples. Accordingly, much of the forest along the actual shore of the reservoir is secondary growth, with an abundance of bamboo (a common indicator of forest disturbance).

The two sites surveyed at Langud (Locations 5 and 6) are in very close proximity to one another (Figure 2) but represent two different river drainages within the same forest area. As a result, much of the sampling during both visits occurred in the same areas. Thus, the difference in total species encountered at these sites (16 and 28, respectively) is most likely a reflection of the difference in sampling effort during each visit (greater man-hours spent at Location 5), or variance in seasonal activity (December and June represent the height and end of the dry seasons, respectively). Sampling at our second Sitio Langud site and at Sitio Talagyo was conducted during consecutive time periods and with similar sampling effort. Therefore, differences in the community composition may reflect the species-specific habitat preferences (less bamboo at Location 7; RMB, personal observations).

With the exception of Location 1, each site visit resulted in one or more species found at none of the other locations (Table 1). All species encountered at Location 1 were also found at other sites. Six species of snakes were found Locations 5 and 6, however, five of these were found only in the Sitio Langud Maliit River drianage, possibly reflecting a seasonal or microhabitat difference in these adjacent sites. Seven species (2 frogs, 2 lizards, 2 turtles, and 1 snake) were found only in the disturbed forest areas surrounding the Bitbit River, and the offices and human settlements near the AWR headquarters. Additionally, three invasive and introduced species, recognized as common human commensals (*Kaloula pulchra*, *Hoplobatrachus rugulosus*, and *Pelodiscus sinensis*), were found only along the Bitbit River. *Gehyra mutilata*, a common house gecko, was collected only from Location 1, but was frequently encountered on buildings at night at Location 3. It is possible that some of these

species represent habitat specialists, occupying a specific ecological niche at the AWR, but the absence of them at other locations may simply be an artifact of limited sampling. Additional surveys are necessary to provide a more complete picture of species distributions, even within disturbed areas.

The results of this study bring the total number of known amphibian and reptile species in the Angat Dam Watershed to 63, and the total number of species reported for Bulacan Province to 68. We expect this number to be an underestimate of actual species diversity of this protected watershed for a variety of reasons related principally to sampling limitations and logistical challenges of accessing all corners of the watershed reserve. Future surveys should be conducted during the peak rainy season as well as in additional sites throughout the preserve. By revisiting sites, sampling a wide variety of habitats, surveying multiple river drainages, and concentrating surveys at different times of the year, Brown *et al.* (2000a) and Siler *et al.* (2011) increased documented species diversity at a forested region in Aurora Province (just north of Bulacan Province) from 49 to 82 species. We expect a similar increase at Angat if repeat survey efforts, sampling across year-round seasonal variation, are conducted. For example, limited collections in the Municipality of San Miguel (to the northwest of Angat) have resulted in one species of frog (*Fejervarya cancrivora*), and one gecko (*Hemidactylus brooki*) not yet observed in Angat. Similarly, surveys in Biak na Bato have resulted in records of one species of frog (*Platymantis biak*), one species of gecko (*Gekko carusadensis*), and one snake (*Lycodon muelleri*) not yet recorded in Angat, plus records of five frogs and six lizards that are shared with Angat (Linkem *et al.*, 2010a; Siler *et al*., 2009a). Future studies in the area will not only result in additional species' distribution records, but will also undoubtedly result in the discovery of new, endemic species, previously unknown to science.

Many groups of amphibians and reptiles found within the AWR warrant additional taxonomic study. These include species of the genera *Brachymeles*, *Bronchocela*, *Cyrtodactylus*, *Gekko*, *Gonocephalus*, *Limnonectes*, *Occidozyga*, *Sphenomorphus*, *Philautus*, *Platymantis*, and *Rhacophorus*, all of which contain widespread distributions that span multiple biogeographic barriers for dispersal (Brown and Diesmos, 2009; Welton *et al.*, 2010; Siler *et al.*, 2011). In the last ten years alone, studies involving just a few of these groups have resulted in the discovery of numerous new species from the Luzon faunal region (Brown *et al.*, 1999a, 2000a, b, 2007, 2008, 2009, 2011; Brown and Guttman, 2002; Brown and Gonzalez, 2007; Siler *et al.*, 2009b, 2010b, c, d; Siler and Brown, 2010; Linkem *et al.*, 2010a, b; Welton *et al.*, 2010), adding to a substantial increase in the biodiversity of Luzon and the northern Philippines (Brown *et al.*, 2008; Brown and Diesmos, 2009; Diesmos and Brown, 2011).

How does the diversity and variety of species of amphibians and reptiles within the Angat Watershed impart societal benefits and ecosystem services enjoyed by the Manila public? Why should the people from this major metropolitan area be concerned with the numbers and kinds of frogs, lizards, and snakes that live within the forested region that constitutes their supply of fresh water? Our answers to these considerations stem from the obvious: as sensitive, fragile, and disturbance-susceptible indicators of ecosystem function (Pechmann *et al.*, 1991; Hager, 1998; Welsch and Ollivier, 1998; Lawler *et al.*, 2003), amphibian and reptile communities are uniquely qualified to inform humans of the "health" of their surrounding natural environment and their watersheds (Kremen, 1992; Dufrêne and Legendre, 1997; Carignan and Willard, 2002). With the simple observation that a taxonomically and functionally diverse ecological community equates to a healthy local community (Sodhi *et al.*, 2008; Sodhi and Erlich, 2010), we can assert that herpetological diversity of the AWR suggests that a functionally diverse and healthy ecosystem has been preserved by the management practices of the reserve. There can be no doubt that the expanding human population, encroaching development, and increasing demands of the Manila area present challenges for watershed management in the future (Myers, 1988; Coxhead and Shiveley, 2005; Pulhin *et al.*, 2007). However, for an island nation facing a soaring human population and some of the highest rates of deforestation in Southeast Asia (Kummer, 1992; Liu *et al.*, 1993; Kummer and Turner, 1994; Uitamo, 1999), the AWR represents a critical natural resource that must be carefully managed and preserved as a critical natural resource for future generations of humans – and other vertebrates – that inhabit the Manila area.

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